Office of the Prime Minister's
Chief Science Advisor
Kaitohutohu Mātanga
Pūtaiao Matua ki te Pirimia

5G in Aotearoa New Zealand

What is 5G?

5G stands for 5th generation. It's the latest cellular network after 2G, 3G, and 4G. The 5G network is more technologically advanced and implementation has begun throughout the world and here in Aotearoa New Zealand.

All cellular networks use radio waves to transmit data. Like light, radio waves are a type of electromagnetic radiation. Radio waves have been used in NZ for radio since the 1920s and cell phones since the 1980s. Like waves breaking on the beach, radio waves can vary in intensity (how big they are) and in frequency (how often they arrive, which is related to how far they are apart, wavelength). The frequency (or wavelength) and intensity of an electromagnetic wave determines how much data the waves can carry and how strong the signal will be, as well as whether the waves are harmless or not.

The initial roll out of 5G in NZ will use frequencies in the same range as 4G. In the future, the network will use a higher frequency (lower wavelength waves) - known as millimetre waves. These are closer in frequency to those used for satellite communications and some vehicle radars. Millimetre waves are also used in microwave ovens but at much higher intensity so they can heat food.

Millimetre waves don't penetrate obstacles as easily, so 5G networks will need more towers than 4G to achieve the same coverage. Although this will not generate enough intensity to create noticeable heating, there will still be international standards in place to limit overall exposure, and monitoring to double check that this doesn't happen. The standards are set with a large safety margin to ensure that the total exposure to radio waves is comfortably below safety thresholds for impacts from heating. NZ follows these international standards.

There have been some concerns about the security of the 5G network, because it is more reliant on software than 4G and uses cloud computing. NZ's Government Communications Security Bureau (GCSB) is aware of this and will act to prevent and minimise security risks to our communication technologies as we adapt to the new technology.

The currently available scientific evidence makes it extremely unlikely that there will be any adverse effects on human or environmental health. NZ needs to continue to monitor the risks of exposure and ensure that they are within the international safety standard, as well as keeping a close watch on any new research.

Roll out in New Zealand

Trials and roll out

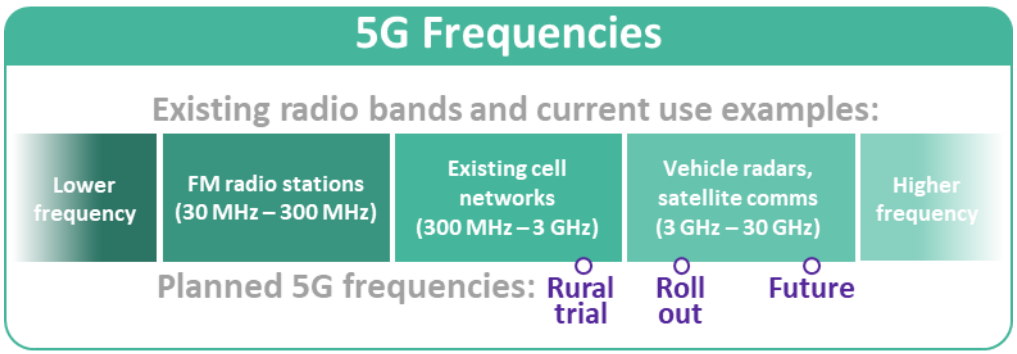
In NZ 5G is already being trialled by Spark and Vodafone, and infrastructure is being set up for wider launches in late 2019 and into 2020. A small number of businesses in Alexandra have been able to trial Spark's 5G, and the company plans to extend it to at least five more regional towns this year and next. Vodafone intends to roll 5G out to Auckland, Wellington, Christchurch and Queenstown in December 2019.

Even though 5G is being rolled out, most devices currently available lack 5G capability. Unlike 4G, the 5G transmitters are only active on demand (see *5G, beamforming and massive MIMO*), so the potential for exposure will be extremely low until consumers purchase 5G capable phones with 5G plans. A few phone models that have been released in 2019 are 5G capable, but this will be more common in phones released from 2020 onwards.

Frequencies to be used

The rollout will use similar wavelengths to those used for 2G, 3G and 4G. For example, the trial in Alexandra used the 2.6 GHz band, which is used in other parts of the country for 4G. The intention is for a slightly higher 3.5 GHz wavelength to be used in more extensive rollouts. Using different wavelengths for different networks is important to avoid interference, causing issues with reception.

Further into the future, higher frequency bands (like 26 GHz) may be used. This wavelength is known as millimetre waves. Radio frequency use is regulated in NZ to avoid issues with interference, to coordinate internationally, and because it's a commercial resource. The government will need to decide if and how they will allocate this spectrum. There is currently some use in this frequency band (such as radars used by some vehicles), but it is otherwise unused in NZ.


5G Frequencies
Existing radio bands and current use examples:
Lower frequency
FM radio stations (30 MHz – 300 MHz)
Existing cell networks (300 MHz – 3 GHz)
Vehicle radars, satellite comms (3 GHz – 30 GHz)
Higher frequency
Planned 5G frequencies:
Rural trial
Roll out
Future

Network infrastructure

Rolling out 5G will require new infrastructure. There are opportunities for telecommunication companies to share infrastructure to reduce costs and make 5G more accessible, particularly in rural areas. There is already a Rural Connectivity Group established between operators so they can share resources and expand coverage for 4G, and this forum could potentially be used to roll out and expand 5G as well. Sharing infrastructure would reduce the number of structures that would be installed, which could reduce some aesthetic concerns. Visual impacts are also regulated by the Ministry for the Environment.

Potential benefits

5G is seen as an attractive technology because:

- **It is faster**. 5G will have faster upload and download speeds compared to 4G. For companies that need to access large datasets, the shorter download speeds will have massive productivity benefits. A trial in Alexandra, Otago reported speeds 5-20 times faster than existing 4G.
- **It has lower latency.** 5G will have a shorter delay before you can access the content you are downloading – with entertainment benefits (e.g. streaming and gaming) as well as educational ones (e.g. downloading multi-media resources in schools). It will also enable new technologies and applications in transport (including driverless cars), medicine and other areas.
- **It offers more connectivity**. More devices will be able to connect to each other – the 'Internet of Things' – like better remote control of the gadgets in your house from your phone.
- **It has a larger network capacity**. 5G will have a greater capacity for volume of traffic so e.g. more people can livestream the same event without buffering issues.

NZ is physically isolated and 5G enables better connectivity with the rest of the world. Adopting 5G in line with the international community will ensure communication channels are compatible, enable research and development of new technologies, and enable use of new tools to help improve our lives.

Within NZ, rural connectivity is an ongoing issue. 5G offers potential for improvement over services currently available if significant investment and cooperation between the network operators is in place. The Rural Connectivity Group could play a role in bringing 5G to rural areas.

The 'Internet of Things' already exists – it refers to devices talking to other devices. For example, wearing smart watches that connect to smart phones and can control smart home devices (like heating, lighting, and security systems). The internet of things is currently limited by the capacity, speed and responsiveness of the 4G network. 5G will be needed to enable new technologies such as self-driving cars, in-home elder and medical support, and use in industries such as manufacturing or precision farming.

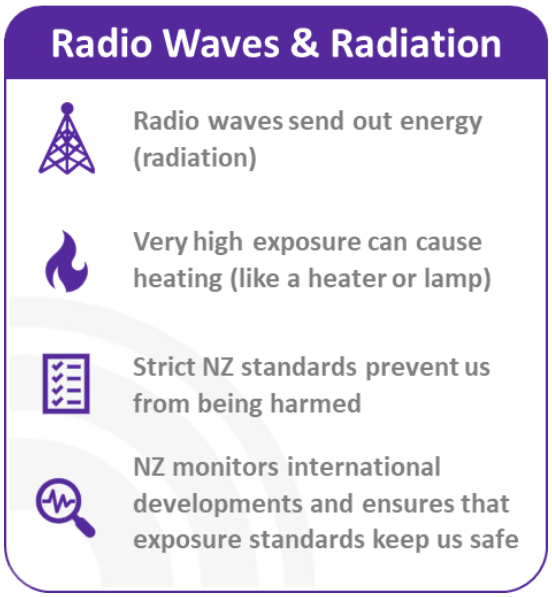
Why are some people concerned about 5G?

Caution about the expanding role of technology

5G presents exciting opportunities that have the potential to improve many areas of peoples' lives by facilitating more access to more technology. Some may see this expansion of technology as detrimental, raising issues of privacy, surveillance, and displacement of certain types of jobs. Any benefits must be weighed against these concerns.

Health

Radio waves used by 5G are a type of radiation, so it's reasonable to ask whether this poses a risk and, if it does, to ensure people are not exposed beyond safe thresholds. Radiation is the way that energy travels through space and there are many different types. Light, for example, is a form of radiation that is so common that we often don't think of it in that way.


Radio Waves & Radiation
Radio waves send out energy (radiation)
Very high exposure can cause heating (like a heater or lamp)
Strict NZ standards prevent us from being harmed
NZ monitors international developments and ensures that exposure standards keep us safe

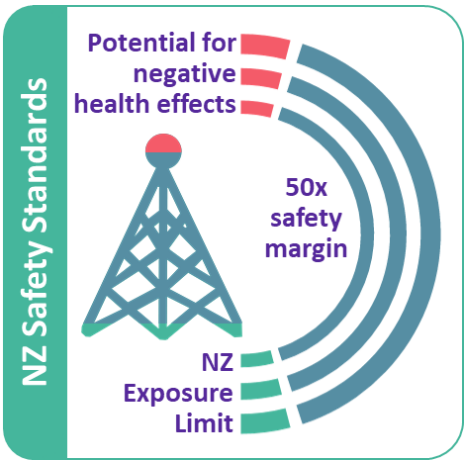
Radiation that has frequencies higher than that of visible light, like the ultraviolet radiation rays in sunlight, and X-rays, can damage the cells in our bodies, potentially causing cancer if exposure is high. These types of waves are called 'ionising radiation', which reflects their ability to break the chemical bonds in molecules, which can damage cells. So exposure to sunlight is linked with skin cancer for those who spend a lot of time in the sun without protection.

In contrast, the radio waves used for 5G have frequencies that are ten thousand times too low to damage molecules (so are called 'non-ionising'). The only fully documented way 5G radio waves can cause harm is through their heating effect and this can only happen at very high intensities.

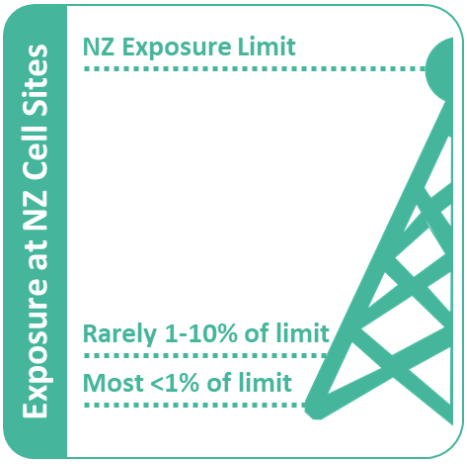
Thermal effects of radio waves

Radio waves can heat our body if we are over-exposed to them. However, these effects can only occur when exposed directly to a very powerful source so that the heat builds up enough to damage tissue before it dissipates. 5G sources are simply not powerful enough to cause damage in this way.

As the thermal effects of radio waves are well-understood, the limits at which they can potentially begin to cause harm are clearly defined. NZ has set its own standards, which are much lower than this limit (about 50 times lower). This means that there is a large safety margin built into our standard.



In practice, the public has a far lower radio wave exposure than the NZ limit. This low exposure is checked by independent monitoring undertaken at cell sites every year.



Thermal effects are well-understood and research in this area continues to be monitored. In NZ, the Ministry of Health has an expert advisory committee that monitors and reviews all new research. The World Health Organization (WHO) also continually investigates possible health effects, as well as other international groups like the Swedish Radiation Safety Authority. The Swedish Authority released a robust and comprehensive review this year, quoting 'no health risks with weak electromagnetic fields have been established…' The authors emphasise the need for ongoing research as 5G begins rolling out globally, to ensure that this remains the case. The importance of ongoing research is actively supported in NZ.

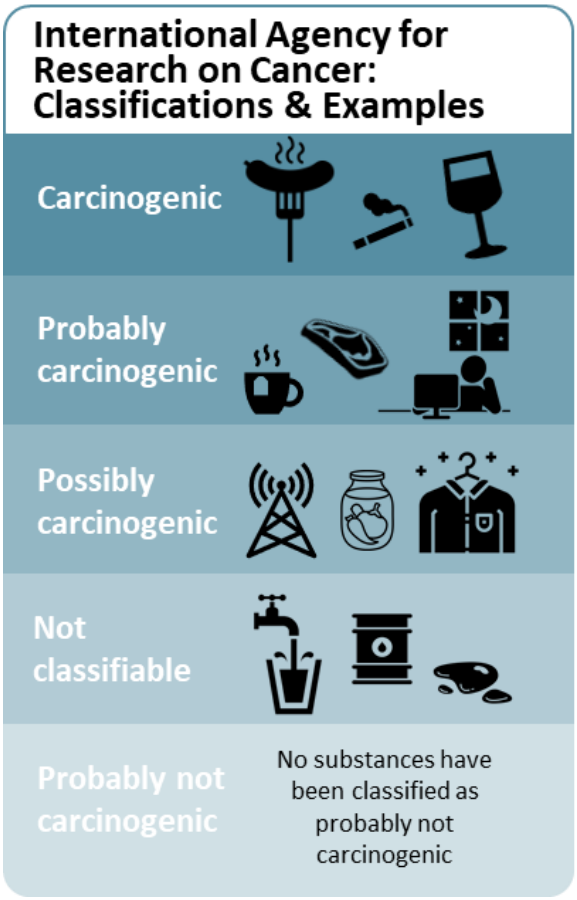
> 'No health risks with weak electromagnetic fields have been established…'

Could radiofrequency radiation be associated with cancer?

As one of the leading causes of death, a huge amount of research goes into trying to understand how to minimise the risk factors for developing cancer. For any individual, it is impossible to tell for sure what caused their cancer but, for populations as a whole, some exposures have strong connections – e.g. tobacco smoking and lung cancer. Because individuals are exposed to many, many different things during a lifetime, there are many substances (known, probable or possible human carcinogens) that are monitored by agencies.

Many researchers have explored possible connections between radio frequency radiation and cancer and as is often the case when there are many separate studies, a small number have reported an association between exposure and cancer, such as mobile phone use and brain tumour risk. There are also isolated lab studies where cells exposed to radio frequency show changes that could be associated with increased cancer risk. These studies are in the minority (e.g. see here). Significantly more high-quality studies have found no associations, including studies funded by cancer research organisations. Scientists have looked at all of the research and weighed up each study, looking at factors like the study design, level of association or certainty, and whether results have been repeated by other studies. The clear conclusion reached internationally, supported by health authorities in New Zealand, is that exposure to this type of radiation at levels experienced in New Zealand is not hazardous.

So why was radiofrequency radiation classified as a 'possible human carcinogen'?


International Agency for Research on Cancer: Classifications & Examples
Carcinogenic
Probably carcinogenic
Possibly carcinogenic
Not classifiable
Probably not carcinogenic
No substances have been classified as probably not carcinogenic

Radiofrequency radiation was classified as a possible human carcinogen by the International Agency for Research on Cancer (IARC) in 2011. This category catches many commonly encountered things, such as pickles and dry cleaning, so represents a low risk rating. To put this in perspective, even the classification above this, 'probable human carcinogens,' includes widely encountered activities including drinking very hot drinks and working night shifts.

The IARC decided on this classification based on studies mentioned here that did report an association with mobile phone use – notably studies by the Hardell Group and one by Interphone. The associations found in the studies are not clear-cut. For example, some results have not been able to be replicated, and others showed low levels of phone use had a protective effect (reduced risk). The classification is based on work on exposure of people to radiation from handsets not cell towers.

The IARC highlights possible hazardous substances but does not look at likely exposures there will be to that hazard, so the rankings err on the side of caution.

'...no adverse health effects have been established as being caused by mobile phone use.'

In contrast, health organisations and government bodies generally include real-world exposures to ascertain the actual risk. The World Health Organization has stated that 'to date, no adverse health effects have been established as being caused by mobile phone use'. The focus of health organisations is generally on lowering risks – for example, by lowering exposure to things that could potentially have adverse health impacts at high levels.

The currently available scientific evidence makes it extremely unlikely that there will be any adverse effects on human or environmental health from radiofrequency. However, an association between radiofrequency and cancer cannot be completely ruled out and this is why the exposure standards are so precautionary. NZ needs to continue to monitor the risks of exposure and ensure that they are within the international safety standard, as well as keeping a close watch on any new research.

What about other symptoms?

People have also expressed concern that radio waves could have other health impacts like headaches, difficulty concentrating, and impaired sleep quality. Neither short nor long term studies have shown conclusive evidence of any of these or other health effects. There have been repeated observations of a small effect on the electrical activity of the brain but there is no clear evidence that this is associated with any harm. The Australian government has responded to concerns by publishing tips on how to reduce exposure at a personal level to enable people to make a choice about their exposure.

Examples include using speaker phone on mobile phone calls and reducing the amount of time using wireless devices.

What about exposure near cell towers?

Since the NZ standard limits potential exposure, it is important to check that this limit is not exceeded near cell sites, especially when new towers are being installed. To control this, the Ministry for the Environment has additional standards that cover activities like installing new poles and antennas, antennas on building, and adding small-cell units to existing structures. This ensures that potential exposure at all locations are significantly under safe limits.

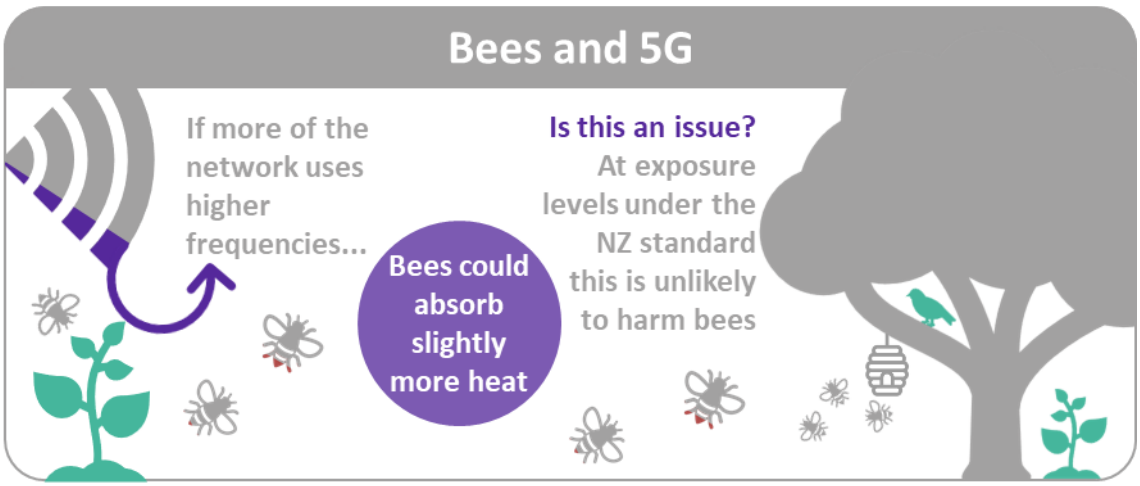
Are there risks to the environment?

Bees and other small animals

Computer simulations find that insects will absorb more heat from radio waves at higher frequencies than they do from the lower ones currently widely used.

Changing the frequency of transmission could in theory make a difference to bees and other insects, however, it has not been shown that this small amount of extra heat absorption causes insect populations any harm or that insects would be more exposed in a real-world environment.

There are many natural sources of variation in environmental heat – like sunshine on a clear day compared to a cloudy one – and research has also shown that bees are being adversely impacted by climate change. Bees are very important to our ecosystem so further research and monitoring around radiofrequency could be valuable even if the likelihood of real-world effects is low.


Bees and 5G
If more of the network uses higher frequencies...
Bees could absorb slightly more heat
Is this an issue?
At exposure levels under the NZ standard this is unlikely to harm bees

Aesthetics

Millimetre wave 5G signals need line of sight to work effectively, which means that there will need to be many more small transmitters, compared to the smaller number of larger towers we use for 3G and 4G. This is not a health or safety issue, but depending on the design of the towers, they may not be visually pleasing. As with other structures, visual effects are considered under the Resource Management Act, managed by the Ministry for the Environment.

Plants

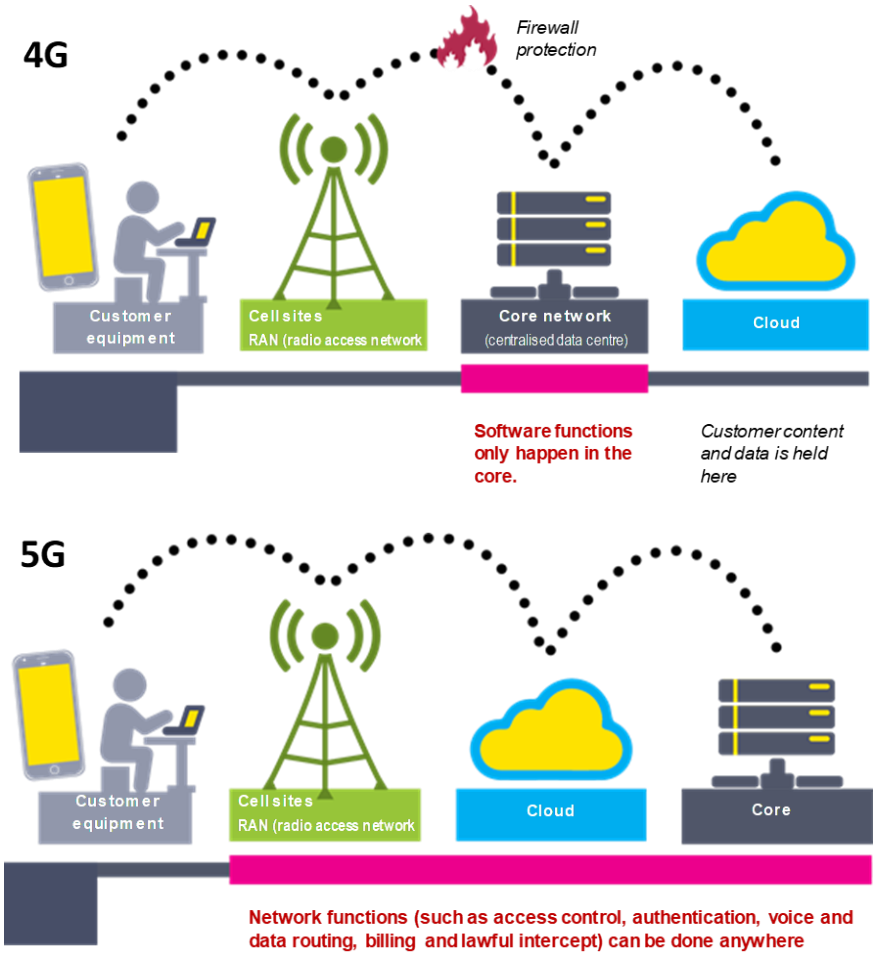
There are concerns that trees may be removed because they can weaken signals and reduce 5G coverage if they are in the signal path. Other objects can also prevent signals – buildings, walls, and other solid objects. Trees are offered protection in NZ under the Resource Management Act.

Technological differences between 4G and 5G

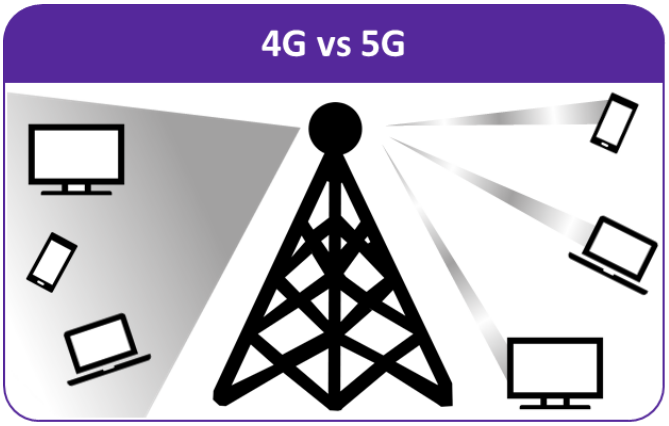
Security

There are a few design differences that affect security in 5G networks, compared to previous generations. While 4G holds sensitive data on a chip, 5G moves this into the cloud so data can be accessed more readily. The diagram below shows a simplified representation of this difference. 5G networks also have a more complex network model that uses advanced computer processing. The difference in design creates potential security vulnerabilities as it becomes more difficult to define and protect sensitive information in defined parts of the network.

Security vulnerabilities can be managed by use of software and comprehensive management of networks. Research on security is ongoing in NZ, as in Australia, the UK and the US.



5G, beamforming and massive MIMO



Another key difference in the 5G network compared to previous generations of cell networks is the use of beamforming technology. Beamforming is enabled by tech called MIMO (multiple input multiple output) base stations – these have many more antennae than 4G bases.

Beamforming is technology that directs radio waves to a target in a way that is more efficient and improves signal quality compared to 4G. The signal only forms when it's needed (like when data is being downloaded), so the potential for exposure is smaller compared to 4G.

Australian companies have reported that in practice, 5G signals are well below safety limits. This has also been found in independent audits. While 5G may use more cell sites, the amount of exposure from each site will be lower as the number of sites grow. There is little evidence to suggest that exposures in NZ would significantly increase with 5G, and the regulation and monitoring in place already limits exposure.

5G and millimetre waves

See *Frequencies to be used*.

Treaty of Waitangi

The 5G network could potentially use a higher frequency (the 26 GHz band), though the government would first need to allocate this spectrum to operators. There is an unresolved Treaty claim over radio spectrum, which the government will need to consider and resolve in allocating this spectrum. There have been several past claims, asserting that radio spectrum is a natural resource (to which Māori have equal rights). Māori have created success and increased participation in the information and technology system previously through purchase of radio frequency in the 3G spectrum.

Resources

Clear science explainers

Does 5G pose health risks? – BBC News (15 July 2019).

The Science of Why 5G Is (Almost) Certainly Safe For Humans – Forbes (1 November 2019).

Who should we trust about 5G? – Newsroom (11 October 2019).

Are mobile phones really bad for our health?– NZ Herald (18 May 2019).

What's the impact of 5G? – BBC Click (15 November 2019). YouTube video.

Australian radiation safety agency fires back at 5G health fearmongering – ZDNet (18 November 2019).

Expert discusses health issues around launch of 5G in New Zealand – NewsHub (19 November 2019). An interview with scientist sharing his opinions and concerns about 5G.

NZ government info

5G and Health – Ministry of Health (August 2019). An overview of health information on 5G and Ministry of Health activities.

5G questions and answers– Ministry of Health (November 2019).

Research into non-ionising radiation – Ministry of Health. Summary of NZ's Interagency Committee on the Health Effects of Non-Ionising Fields, which monitors research into extremely low frequency electric and magnetic fields, and radiofrequency fields.

Radiofrequency field exposure standard – Ministry of Health. NZ standards on exposure.

Independent cell site monitoring - Ministry of Health. Information and results of independent cell site monitoring.

Environmental standards for telecommunication facilities – Ministry for the Environment. A guide that explains the national environmental standards: what they do, why they have been introduced, and how they affect you in your daily life.

Preparing for 5G in NZ – Radio Spectrum Management. Process of preparing for 5G.

5G on track for 2020 – Beehive (February 2019). Press release on 5G spectrum allocation.

Statement on 5G – Government Communications Safety Bureau (November 2018). Statement on 5G and further information on what 5G is.

International government information

UK briefing paper on 5G – UK Parliament (September 2019). The briefing includes an explanation of 5G and its expected uses; policy challenges associated with 5G and information about the roll-out of 5G in the UK including forthcoming spectrum auctions.

5G technologies: radio waves and health – Public Health England (October 2019).

5G: the new generation of the mobile phone network and health - Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) (March 2019). 5G, health, and standards.

Misinformation about Australia's 5G network – ARPANZA (June 2019).

House of Representatives Standing Committee on Communications and the Arts: Inquiry into the deployment, adoption and application of 5G in Australia: Submission 330 – Submission on 5G in Australia.

US policy on 5G technology – US Foreign Press Centre (August 2019). Briefing on US policy on 5G technology.

Overview of Risks Introduced by 5G Adoption in the United States – Cyber and Infrastructure Security Bureau (July 2019). Overview of opportunities and challenges, implementation, deployment, and network security in the US.

Health

5G and Health – Ministry of Health (August 2019). An overview of health information on 5G and Ministry of Health activities.

Research into non-ionising radiation – Ministry of Health. Summary of NZ's Interagency Committee on the Health Effects of Non-Ionising Fields, which monitors research into extremely low frequency electric and magnetic fields, and radiofrequency fields.

Recent Research on EMF and Health Risk – Swedish Radiation Safety Authority (June 2019). Comprehensive review of new research by Swedish Radiation Safety Authority's Scientific Council on Electromagnetic Fields.

Radiofrequency Electromagnetic Fields – International Agency for Research on Cancer (2013). Monographs on the evaluation of carcinogenic risks to humans (Volume 102).

United States information sheet – National Cancer Institute (January 2019). Information on electromagnetic radiation.

5G: the new generation of the mobile phone network and health - Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) (March 2019). 5G, health, and standards.

Submission to the House of Representatives Standing Committee on Communications and the Arts Inquiry into 5G in Australia - Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)

5G technologies: radio waves and health – Public Health England (October 2019).

Standards and monitoring

Radiofrequency field exposure standard – Ministry of Health. NZ standards on exposure.

Independent cell site monitoring - Ministry of Health. Information and results of independent cell site monitoring.

High frequency 100 kHz - 300 GHz – International Commission on Non-Ionizing Radiation Protection. International basis for NZ standards.

Electromagnetic Fields Standards and Guidelines - World Health Organization. Information on standards and guidelines internationally.

Security and innovation

Statement on 5G – Government Communications Safety Bureau (November 2018). Statement on 5G and further information on what 5G is.

Telecoms supply chain – UK Government (2019). Comprehensive review of supply arrangements for the UK telecoms Critical National Infrastructure.

Overview of Risks Introduced by 5G Adoption in the United States – Cyber and Infrastructure Security Bureau (July 2019). Overview of opportunities and challenges, implementation, deployment, and network security in the US.

How will 5G shape innovation and security: A Primer – Center for Strategic and International Studies, US (2018).

FAQs

How is 5G different from 4G?

See *Technological differences between 4G and 5G*.

What are the benefits of 5G?

See *Potential benefits*.

Where will 5G be?

5G is being implemented in countries throughout the world. In NZ it has been trialled in Alexandra, and there are plans to launch it in main cities in December 2019 (Auckland, Wellington, Christchurch and Queenstown), and at least five regional towns in 2019/2020.

Which wavelengths will be used in NZ?

The wavelength 5G will use in NZ will initially be 3.5 GHz. This is similar to wavelengths used for 2G, 3G and 4G. The wavelengths for each radio type must be different to each other to prevent reception issues.

In the future, a higher frequency (26 GHz) may be used. This higher wave type is known as millimetre waves. There is currently some use in this frequency band (such as radars used by some vehicles) but it is otherwise unused in NZ.

Will 5G interfere with weather sensors?

This is not currently a concern in NZ as 5G will use the 3.5 GHz band. NIWA has confirmed this use won't interfere with weather forecasts.

NZ 5G may expand into a higher band in the future – the 26 GHz band, which covers frequencies from 24.25 GHz to 28.35 GHz. The lower end of the band is close to the frequency that water absorbs at (23.8 GHz), which means 5G could potentially cause interference to weather forecasting if it's not carefully managed. This is a key area that is being researched and will be addressed in international standards.

Will I be exposed to radiation?

See *Health*.

Will there be more exposure to radio waves?

It is difficult to say whether exposure will increase or decrease. The use of 5G beamforming technology allows radio waves to be directed to a target only when needed.

Australian companies have reported that in practice, 5G signals are well below safety limits. This has also been found in independent audits. While 5G may use more cell sites, the amount of exposure from each site will be lower as the number of sites grow. There is little evidence to suggest that exposures in NZ would significantly increase with 5G, and the regulation and monitoring in place already limits exposure.

Is there more exposure further from towers?

Exposure to radiation decreases rapidly as distance from the source increases – this is true for cell towers, cell phones, and any other sources that emit radiofrequency radiation.

What standards do Telecommunication companies need to meet?

Thermal effects of radio waves are well-understood, so the limits at which they can potentially begin to cause harm are clearly defined. NZ standards have a built in safety margin and operators must ensure they meet these standards.

Who can use 5G?

The majority of devices currently available do not support 5G. A few phone models released in 2019 are 5G capable, but this capability will become more widespread in phones released in 2020 onwards. Even with 5G capable devices, 5G networks will not be available everywhere in NZ, and the phone plan used must cover 5G.

Why are people worried about security?

See *Security*.

Will 5G cause cancer?

See *Health*.

Why has Brussels stopped their 5G rollout?

The rollout of 5G in Brussels has been delayed for two main reasons:

- **Disagreement on how proceeds from auctioning radio bands used for 5G should be distributed.** The disagreement means the radio bands are not expected to be auctioned until around 2020.
- **Concerns that the antennae used for 5G may not be able to measure radiation output accurately.** This means it would not be known for certain whether 5G networks would not exceed radiation limits.

Since 2009, the Brussels region has had stricter radiation standards than most other countries. The stricter limits are not evidence based, rather due to the precautionary principle and public pressure. The stricter limits have previously caused issues with providing fast mobile internet in Brussels.

Although there are no 5G licenses for sale, Brussels has one operator that already has a license they can use for 5G networks (the 3.5 GHz band). They are working with a port to set up a private 5G network for use on their tugs, barges, and operations.

Why have scientists petitioned against 5G?

There are various international petitions against 5G that have been signed by people, including some scientists. However, as NZ and international reviews and research have found, it is unlikely that exposure within NZ limits is associated with adverse health effects.

Who is monitoring 5G safety?

Independent compliance monitoring is undertaken of cell sites in NZ. The exposures are generally less than 1% of that allowed under the Standard.

The Ministry of Health has an expert advisory committee that monitors and reviews new research. The committee meets every six months and must inform the Minister of Health of any reasonable suspicions of health hazards.

The World Health Organization (WHO) also continually investigates possible health effects of electromagnetic fields, including radiofrequency fields from radio transmitters.

Could 5G be used as a weapon?

5G use in NZ will not operate at frequencies or intensities that could be used as a weapon. All exposures must continue to be under NZ standards and these are independently and frequently monitored.

Will 5G harm bees and other insects?

See *Bees and other small animals*.